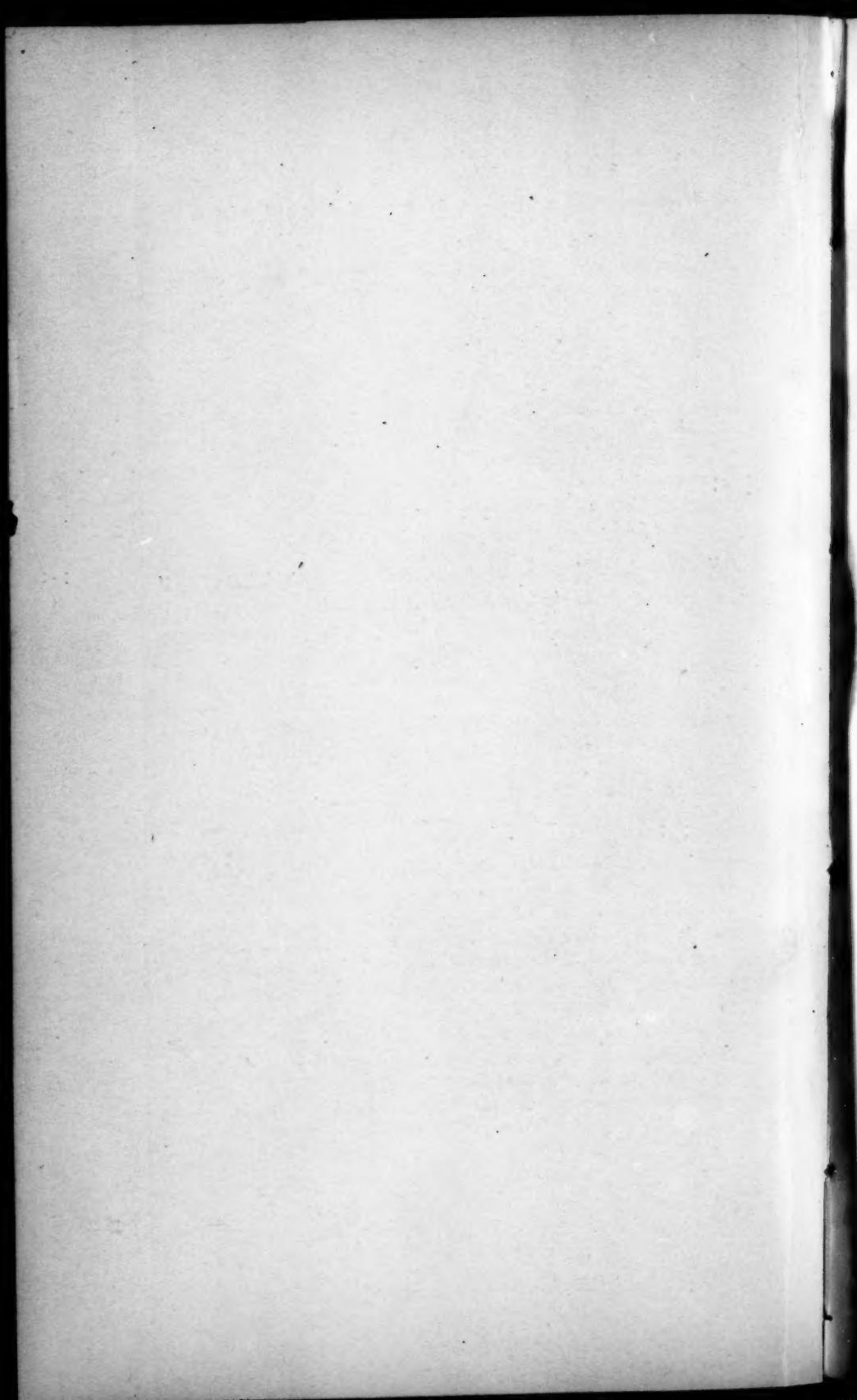


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***ON THE FIRST OBSERVATIONS WITH REGISTRATION
BALLOONS IN AMERICA.***

BY A. LAWRENCE ROTCH.



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In a communication to the Academy in 1897,* the author described the so-called "ballons-sondes," which had been first employed in Europe a few years before to ascertain the meteorological conditions of the high atmosphere. He also gave an account of the more recent use of kites at his own Observatory on Blue Hill to investigate the conditions prevailing in the free air at lesser heights. In concluding he expressed the wish, as the American member of the International Committee for Scientific Aeronautics, that similar explorations of the high atmosphere with the "ballons-sondes" might be attempted in America.

Although the successful experiments at Blue Hill led to the extensive use of kites for meteorological observations abroad, the "ballons-sondes" were not tried in America until 1904, when the author was enabled to make a series of ascensions at St. Louis through the co-operation of the management of the Louisiana Purchase Exposition. A grant of \$2,500 was authorized, but only about half this sum was spent for apparatus, travelling and living expenses.

In Europe two types of these balloons have been employed recently; viz., large balloons of silk or paper and small balloons of india-rubber, all being filled with hydrogen gas. The economy and ease of inflation, with the advantage of a quick ascension to the culminating point and restricted drift, led to the adoption in the St. Louis experiments of the latter form, devised by Dr. Assmann, director of the Royal Prussian Aeronautical Observatory, and made by the Continental Caoutchouc and Gutta Percha Company of Hanover, Germany. The balloons used had an initial diameter of approximately six feet when inflated with about 100 feet cubic feet of hydrogen gas, and carrying parachute and instrument exerted a net lift of nearly two pounds, which is sufficient. Being closed at the mouth they rise at an almost uniform rate of speed, expanding meanwhile until they burst at a height which is dependent

* These Proceedings, 32, No. 13.

upon their initial distension. A parachute, covering the top of the balloon, moderates the fall and it reaches the ground comparatively near the point of departure. The times at which the balloon left the ground and returned to it being automatically recorded and these places being known, the average direction and velocity of the balloon can be calculated, although its velocity is usually greater over the upper portion of its course. In some cases two balloons, unequally filled and coupled tandem, are employed, and, as only one balloon bursts, the other is borne slowly to the ground, where it continues to float and serves to attract persons to the spot. If the balloons are not badly torn they may be mended and used again, but, since the rubber has been permanently stretched, its elasticity is impaired and consequently the balloons will not rise as high as before. The quality of the rubber also deteriorates rapidly, especially when exposed to light and heat. The recording instruments, which were furnished by M. Teisserenc de Bort of Paris, consist of a metallic thermometer and a Bourdon barometric tube which record upon a smoked cylinder turned by clockwork. The smoked sheet of aluminum is afterwards removed from the cylinder and the record made permanent by flowing shellac over it. The temperature and barometric pressure are recorded simultaneously, and from them the corresponding curve of height may be computed with tolerable accuracy by Laplace's formula. Although the instruments had been calibrated in Paris, they were again tested before each ascension for barometric pressure under the receiver of an air-pump, in which the natural rate of change of pressure was imitated as nearly as possible, and for temperature in a bath of alcohol cooled with solidified carbon dioxide. Each instrument is contained in a mica case and further protected against rough usage by a wicker basket suitably screened against the sun's rays, the whole weighing about a pound and a half. It is suspended from the parachute at a considerable distance below the balloon and directions printed on a water-proof envelope request the finder to pack the instrument carefully in a box and return it either to St. Louis or to Blue Hill, a reward being promised for the service. A card contained in the envelope, after being filled out with the finder's name and address and the time of finding, is to be mailed immediately to the sender. The fact that all but one of 23 balloons and instruments despatched were found and returned shows the efficiency of these arrangements as well as the excellent topographical situation of St. Louis for this work.

Owing to difficulties in obtaining hydrogen gas on the Exposition Grounds, the experiments were not begun until the middle of Septem-

OBSERVATIONS WITH REGISTRATION BALLOONS DESPATCHED
FROM ST. LOUIS, U. S. A.

Date.	Time of Start.	Minimum Temp. (Deg. F.)	Corresponding Height. (Feet.)	Direction of Flight. (From.)	Distance travel'd. (Miles.)	Minutes in Air.	Velocity. (Miles per Hour.)
1904.							
Sept. 15	4.33 P.M.	-62.5	55,925	WNW.	60	114	26.3
Sept. 23	5.39 P.M.	-64.7	51,120	W.	57	...	...
Sept. 24	5.35 P.M.	-19.7	26,800	W.	60	180	23.1
Sept. 26	4.20 P.M.	† . . .	. . .	WNW.	52	...	...
Nov. 22	5.18 P.M.	-11.6	21,035	NNW.	65	156	25.0
Nov. 23	5.45 P.M.	46.4	7,650	NW.	55	65	50.8
Nov. 24	6.25 P.M.	39.4	8,200	NW.	145	...	...
Nov. 25	6.00 P.M.	-63.9	37,730	W.	280	167	100.7
Nov. 26	5.27 P.M.	-76.2	35,400	NNW.	235	140	100.6
Nov. 29	10.56 A.M.	-20.9	21,330	W.	140	142	59.1
Nov. 29	5.53 P.M.	...	36,075*	WSW.	260	...	...
Nov. 30	6.47 P.M.	...	2,800*	S.	16	28	34.2
Dec. 1	7.25 P.M.	-1.8	21,735	SW.	92	132	41.9
Dec. 2	12.19 P.M.	-72.4	51,870	SW.	105	112	56.2
1905.							
Jan. 22	5.20 P.M.	-70.8	41,570	W.	162	...	...
Jan. 23	5.20 P.M.	† . . .	. . .	WNW.	77	...	...
Jan. 25	5.25 P.M.	-111.0	48,680	NNW.	285	...	...
Jan. 26	5.20 P.M.	-85.2	28,950	NW.	140	...	...
Jan. 27	5.15 P.M.	...	55,090*	NW.	108	...	...
			-4.7	17,160	...	...	...
Jan. 28	5.36 P.M.	-6.7	14,510	WNW.	30	...	...
Feb. 10	...	...	...	W.	250	...	...
March 2	...	...	...	NNW.	68	...	...

* These are the maximum heights, no temperatures being obtained.

† The records of these ascensions were obliterated by the finders.

ber, 1904. During that month four ascensions were made, all the balloons falling about 50 miles east of St. Louis within a distance of 15 miles of one another, and at the maximum height of ten and a half miles a temperature of -62° F. was recorded. Another series of 10 ascensions was made during the closing days of the Exposition in the latter part of November and the first days of December, mostly after sunset to avoid the possible effects of insolation. Owing to the stronger air currents at this season, two of these balloons travelled with a mean velocity of more than one hundred miles an hour and all but one fell within the eastern half of a circle having St. Louis as its centre and a radius of 280 miles. The exception was a balloon which did not rise above the surface wind. In general the drift was away from the areas of low barometric pressure at the ground, thus confirming the theory of the outflow of air above them. An extreme height of almost ten miles was attained, and a temperature of -76° F. was found once somewhat below seven miles.

In order to continue these observations during the winter, the author executed at his own expense another series of nine ascensions during the latter part of January and on the days of the international ascensions abroad in February and March, respectively. The gas required was generated in barrels by the acid process. One of these balloons was lost, but the others fell nearly within the semi-circle described above. Several of the records are incomplete, owing to stoppage of the clock movements, and another was obliterated by the finder, but a height exceeding ten miles was indicated, and the extraordinarily low temperature of -111° F. was registered at the height of about nine miles during the prevalence of a high barometric pressure at the ground. Most of the ascensions were conducted by Messrs. Clayton and Fergusson of the Blue Hill Observatory staff, and it is due to their skill and perseverance in overcoming difficulties, consequent on undertaking a new work away from home, that such good results were obtained. The records have been partially reduced by Mr. Clayton and a summary of them is given in the accompanying table, but the temperatures and heights must still be regarded as more or less approximate. A complete publication will be made with the investigations of the Blue Hill Observatory in the "Annals of the Astronomical Observatory of Harvard College."

The annual variation of the temperature at great heights in the free air above the American continent is not yet known, and to ascertain this the writer will undertake a fourth series of observations with registration balloons this summer at St. Louis, the expense being met by a grant of \$1,000 from the Hodgkins Fund held by the Smithsonian Institution to aid research relating to the atmosphere.

